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THOMAS FORSYTH HUNT, DEAN AND DIRECTOR
H. E. VAN NORMAN, VICE-DIRECTOR AND DEAN, UNIVERSITY FARM SCHOOL

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GRAPE JUICE.

By F. T. BIOLETTI.

This short account of methods of preserving unfermented grape juice is prepared in answer to the very numerous inquiries received at the Station on this subject. No attempt is made to explain in detail all the methods and appliances necessary for preparing grape juice on a commercial scale. Only the fundamental processes and principles are discussed together with enough detail to enable anybody to devise means to conserve small quantities for domestic use, or to judge of the efficacy of industrial methods or installations.

OUTLINE OF PROCESS.

Gathering and Care of the Grapes.
Extraction of Juice.
    Stemming, Crushing, Draining, Pressing.
Preliminary Clearing or Defecation.
    Sulfiting, Settling, Racking, (Fining?).
Final Clearing.
    Pasteurizing, Settling, Addition of Acid, (Fining?), Filtering.
Conservation.
    Bottling, Corking, Sterilizing.

The various steps in the process have two objects—to preserve the juice from spoiling and to make it permanently clear. Both objects should be accomplished with as little change of the flavor of the fresh juice as possible. If the juice is for home consumption and perfect clearness is not necessary, the process can be shortened and simplified. It can be still further simplified by adopting the methods used for ordinary preserving of fruit. In the last case, the fresh flavor of the juice is destroyed and it is not relished by most people.

1. *Gathering the Grapes.* Only good, sound grapes, carefully gathered in a cleanly way should be used. It is best to gather them in the morning while cool, or to leave them all night exposed to the open sky to cool off before crushing.

2. *Crushing and Stemming.* The cool grapes should be thoroughly broken and the pulp crushed by passing between rollers or by some similar method. The seeds should not be broken nor the skins macerated too much or the juice will be harsh, astringent and difficult to clear. On the other hand, if the pulp is not well broken up, the yield of juice will be low.

3. *Separation of Juice.* A considerable portion of the juice will run off if the crushed grapes are allowed to stand for a few hours in a drainage cage. This cage may be the press basket, a box furnished with a false bottom of slats, an open fermenting vat with a good strainer at the bottom, or some similar device.

After draining, the crushed grapes are pressed to extract more of the juice. A cider press or any of the presses used in wineries may be used for this purpose, with the exception of the ordinary continuous presses, which are not advisable, as they macerate the grapes too much and produce a turbid juice that is difficult to clear. The fresh grapes have a tendency to squirt out through the interstices of the press, especially if the stems have been removed, as is generally done directly before or after crushing. This can be prevented by lining the bottom and sides of the press basket with grape stems as it is being filled. Clean straw is sometimes used for the same purpose.

For the best results, the pressing should be slow and gradual. A lever press gives excellent results on a small scale. The pressed "pomace" may be forked over and pressed a second or third time. If any water is to be used, it is best sprinkled on the turned pomace before the second and third pressings.

4. *Defecation.* The free run and the press juice are more or less cloudy, owing to floating particles of skin, pulp, etc. If the grapes are clean and sound, this may not injure the flavor noticeably and for home use it may be bottled immediately and sterilized as explained later. It is very much improved, however, in appearance and somewhat in flavor, by a preliminary "defecation" or clearing. This is obtained by allowing the juice to remain undisturbed in casks or open vats until the grosser particles settle and form a sediment.

This defecation requires from twelve to forty-eight hours, usually about twenty-four to thirty-six. It will therefore be from two to three days after the crushing of the grapes before the clear juice is obtained. During this time, there is danger of fermentation starting, which would spoil the juice. If the grapes are cold when crushed and the weather remains cool, the juice can sometimes be cleared successfully in this way. It is usually necessary, however, to take measures to prevent fermentation. There are two methods of doing this. One is to put the juice into a cold storage room below 50° F. If the grapes are in poor

condition or the juice warm, it may be necessary to have the room much colder than this. The other method is to paralyze, temporarily, the fermentation organisms with sulfurious acid.

The best way of applying the latter method is the use of potassium-metabisulfit. This is used in the form of a ten per cent solution in water at the rate of from 5 ounces to 10 ounces of the sulfit to one ton of grapes or two hundred gallons of the juice. The sweeter and warmer the juice the more sulfit is needed.

The best way of applying the sulfit is to add the solution gradually to the crushed grapes as they fall from the crusher or into the drainage box. In this way, the ferments are prevented from making even a commencement of development and a smaller quantity of sulfit will suffice. The use of sulfit must not be considered as a substitute for care in handling and keeping the grapes cool, but only as an additional precaution against injurious fermentation. The juice should be as cool as is practicable, but may be defecated perfectly by this means if it does not rise above 70° F.

The sulfit must be carefully measured and evenly distributed. If too much is used, it will injure the flavor of the juice. If too little, it may not accomplish its object. An excess of ten or twenty per cent over the amounts indicated will do little or no harm and would still be several times less than the legal limitations for dried fruits and wine.

Defecation by means of sulfurous acid is not only simpler but better than by means of refrigeration. It not only prevents injurious fermentations more effectually, but it prevents undue oxidation of the juice during the processes of preparation. Oxidation is one of the main causes of the loss of the finer flavors of the fresh juice. This is not prevented but rather increased by refrigeration.

5. *Pasteurization.* The prevention of fermentation by means of the metabisulfit is only temporary and, even in cold storage, fermentation will develop slowly unless the juice is kept close to the freezing point. The clear juice, therefore, must be separated from the sediment as soon as it has settled and before even the commencement of fermentation has occurred. At the end of forty-eight hours, at the latest, therefore, it should be drawn off. Even though it still appears cloudy, most of the gross sediment will have settled.

In many cases, it will be nearly bright, and, if intended for domestic use, it is best to bottle and sterilize it at this point. However bright it may be at this point, it is not safe to bottle it for commercial use, as it will become cloudy again in bottle. This new cloudiness is due to crystallization and precipitation; that is, the becoming solid of certain substances which are at first dissolved in the juice. The chief of these substances is the bitartrate of potash or cream of tartar. These substances precipitate slowly, often requiring weeks, or even months.

In order to give the substances time to deposit, the juice is pasteurized to kill the ferments which have been only temporarily paralyzed by sulfiting or refrigeration.

This pasteurizing is sometimes applied to the fresh juice without preliminary defecation. This involves heating the juice while it still contains all its gross sediment. This results in deterioration of flavor, difficulty in clearing, and clogging of the pasteurizer.

Pasteurizing is heating to a degree and for a time sufficient to kill all ferments which are in the juice and are capable of injuring it.

The killing of the germs depends both on the degree of temperature reached and on the time during which this degree is maintained. A momentary heating to 175° F. will kill most yeasts and molds commonly found in grape juice, but at 140° F., some of the resistant spores would escape. If the must is heated to 140° F. and kept at that temperature for several hours, the effect would be equal to 175° F. for a minute.

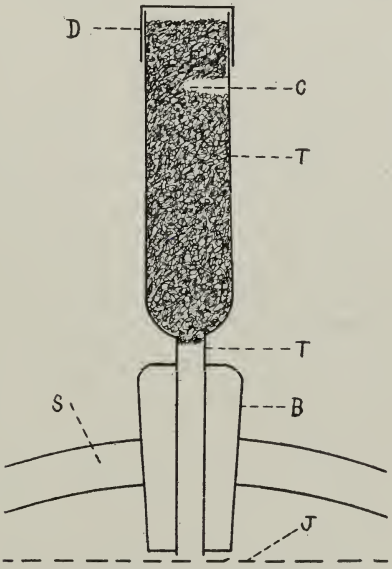
The lower the temperature of pasteurization the less the flavor of the juice is injured. It must be high enough, however, to insure keeping. In practice, with present methods, it is necessary to heat at least to 160° F. If the must is sulfited and run hot into sterilized casks of at least fifty gallons capacity where it will keep hot for some hours, this temperature should be sufficient. If the heated must cools rapidly as when put in bottles, or if the casks are imperfectly sterilized before filling, a higher temperature will be needed. The flavor of the juice is not seriously injured below 175° F. when sulfit is used.

For domestic purposes, the pasteurizing is best done by placing the fruit in large fruit jars or demijohns and heating them, surrounded by water, in a boiler, as is done in bottling fruit. Two thermometers should be used, one in one of the jars, and the other in the water of the boiler. The thermometer in the jar should reach to the bottom where the juice heats more slowly. The covers should be placed loosely over the jars and the boiler should be covered. The water in the boiler should not exceed 175° or 180° F. and as soon as the thermometer in the jar indicates 160° F. at the bottom, the fire should be removed, the covers of the jars screwed down tight and the juice allowed to cool slowly in the covered boiler. These jars may then be kept like those containing preserved fruit. If placed upright, the solids eliminated will form a sediment at the bottom and the clear juice above may be decanted for immediate consumption, or placed in bottles, corked and sterilized as described later.

On a large scale, some form of continuous pasteurizer is more convenient. Some of those used for wine are suitable, providing the tubes or other passages through which the liquid runs are not too small. Pasteurizers having a great length of narrow tubing rapidly become

clogged and the viscid nature of the juice renders the flow difficult and irregular. In pasteurizing wine, the hot liquid must not come in contact with the air. With grape juice, this precaution is not necessary, especially if sulfit has been used. Too much exposure to the air, however, should be avoided, or the juice may acquire an oxidized taste.

The heated wine should pass directly from the pasteurizer into recently sterilized casks. These casks should be sterilized by means of steam and plugged with a wooden bung wrapped with a piece of cloth such as ordinary cotton sheeting. Both bung and cloth should be thoroughly sterilized with boiling water and by soaking in a two per cent sulfit solution. The filled casks are then placed on skids, firmly wedged to prevent movement, and allowed to settle for several weeks.



Air-filtering Bung for Settling Casks. S, stave of cask; J, surface of grape juice; B, wooden bung; T, metal funnel to hold cotton with tube passing through the bung; C, tightly packed sterilized cotton; D, loose fitting metal cap of funnel.

The colder the room in which they are kept, the less danger there will be of fermentation and the more rapidly the juice will get rid of its cream tartar.

The juice will have to settle for several weeks and unless the work is all done carefully, it runs the risk of fermenting. If the casks have been properly sterilized and the juice run in at 160° F., they will be completely free from any germs which could cause fermentation. As the juice cools, however, air will be drawn into the cask by the decrease of volume and, with this air, some fermentation germs may enter.

This may be prevented by use of a device which filters the air through a tight plug of sterilized cotton as it enters. Such a device is shown in the figure.

This air-filtering bung should be put in place of the regular bung as soon as the cask is fixed on its skids and before the juice has had time to cool in the least. The best way, where practicable, is to pasteurize directly into the casks after they have been fixed in their permanent resting places and to insert the air-filtering bung the moment the cask is full.

These air-filtering bungs will be effective only if carefully made and properly handled. The bung hole of the cask should be smooth and regular and each should have its own bung fitted exactly. The metal tube through the bung should fit close so that no air will pass between it and the wood. If it is threaded so as to screw into the bung it will make an air tight joint.

Before using, both filtering funnel and bung should be sterilized. The funnels are first filled with clean surgeon's cotton, packed fairly tight and the loose metal caps put in place. They are then rolled in pieces of manila paper kept in place by folding over the ends. The wrapped funnels are then heated for an hour in an oven hot enough to just slightly char the paper. A number of wrapped funnels may be sterilized in a metal box and kept in this box until needed.

The bungs are sterilized by dipping in boiling water and then soaking until needed in a 2 per cent solution of sulfit.

If the funnels and bungs are carefully handled, they can be inserted into the casks without danger of contamination. As soon as a bung is inserted into a filled cask, it is tapped in firm and the cask immediately rolled a little on one side. The cask should be rolled over sufficiently to immerse the lower end of the bung in the hot juice but not so far that there is danger of wetting the cotton in the funnel.

With all these precautions, a cask of juice may occasionally ferment. In such cases, the juice can be used for vinegar. With intelligent care, few or none of them should spoil in this way. The air-filtering bung acts as a safety valve for the occasional cask which ferments and which without this outlet might blow out a head.

6. *Final Clearing.* A few weeks of settling, after pasteurizing, will sometimes render the juice perfectly bright. In this case, the permanency of the brightness should be tested. This may be done by heating a corked bottle of the clear juice to 160° and then allowing it to stand for several days in a cool place. If the juice remains clear, it may be bottled. If it becomes cloudy, it should be allowed to stand several weeks longer.

In some cases the juice will not become clear even after prolonged settling. It is then necessary to filter it before bottling. It should

be tested by filtering a few bottles, heating and allowing to stand as explained above before bottling the whole quantity.

In nearly all cases, even when the brightness appears permanent by these tests and the juice is put in the bottles clear, there will be a further deposit with time. This should be very slight, however, and should consist only of fine crystals of cream of tartar. The formation of these crystals in the bottle will be prevented if a small quantity of citric acid is added to the juice before filtering. The addition of this acid is also nearly always advisable to improve the flavor of the juice, which with ripe vinifera grapes tends to be lacking in acidity. Tartaric acid will improve the flavor in the same way but will not prevent the formation of crystals. From one to two pounds of citric acid to a hundred gallons of juice is all that is needed.

7. *Sterilizing.* The clear filtered juice should pass directly into bottles which should be corked and sterilized without delay.

The bottles should be carefully cleaned and sterilized with boiling water before filling. It is even more important that the corks should be thoroughly sterilized. The sterilization of the corks is more difficult as resistant mold spores may be lodged in the crevices. It can be accomplished by immersing the corks for five minutes in boiling water to which has been added 1 per cent of copper sulfate. The corks should then be kept in 2 per cent solution of metabisulfit until used. Where caps are used, there is also danger of molding unless they are sterilized. Copper sulfate can not be used in this case as it would attack the metal of the caps. Boiling in pure water for fifteen minutes can be recommended.

As soon as the clear juice is bottled and corked, it should receive its final sterilization. This can be done by any means which raises the temperature of the juice in every part of the bottle to 160° F. This temperature should be maintained for at least five minutes. If the bottles are placed upside down or in such a position that the cork will be wet with the juice during sterilization, less trouble will be experienced from subsequent molding of the corks.

The bottles must not be filled too full or the expansion of the juice in heating will drive out the cork or burst the bottle. An air space of about $1\frac{1}{2}$ inches in the neck is necessary. Even then the corks may be driven out by the compressed air, so it is necessary to fasten them in by tying with string or with some of the devices made for this purpose. When the sterilizing is done in a closed sterilizer or "autoclav," fastening the corks is not necessary.

8. *Fining.* The clearing of the juice may be much facilitated and hastened in many cases by "fining." This consists in adding to the juice a minute quantity of a substance which will coagulate and settle in the liquid, carrying down with it all the particles of solid matter

which cause the cloudiness. This fining can be applied at the time of the first pasteurization or just before the final filtration and bottling.

In the first case, just as soon as the juice is cleared by defecation, it should be drawn off, thoroughly mixed with the finings and pasteurized into the settling barrels immediately.* In the second case, the juice from the settling casks is drawn off, mixed with finings and pasteurized again into other casks. After remaining until clear, it is bottled directly and sterilized. Instead of allowing it to settle after this pasteurization, it may be passed while still hot through a filter and bottled directly. When this is done, the juice often becomes cloudy again a short time after bottling. If the juice after fining and heating is allowed to stand for a few hours it can often be made permanently clean by filtering.

The usual method is to fine the juice after settling for several months. In this case, an extra heating is necessary just before bottling. If the fining is done before settling this extra heating is unnecessary.

9. *Materials Used for Fining.* The materials used in fining wine can be used for grape juice. The amounts used, however, will differ, owing to the greater cloudiness of the juice and the presence of albuminoid matters.

The commonest finings used for wine is equal amounts of tannin and gelatin. If gelatin is used in grape juice, a much larger amount of tannin will be necessary. Good results have been obtained by the use of 5 ounces of tannin and 2 ounces of gelatin to 100 gallons. Two to three ounces of tannin without the gelatin would probably be effective in some cases as the tannin would form a precipitate with the albuminoid matters of the juice. The tannin should be completely dissolved in a little hot water and thoroughly mixed with the juice before adding the gelatin. The gelatin should then be dissolved in hot grape juice and thoroughly stirred into the juice. These finings can be recommended for use before settling.

Dried egg albumen at the rate of 4 ounces to 100 gallons of juice without tannin may be used for the late fining but has not given good results before settling.

The best results for early fining, before settling, were obtained by the use of Lactocol or Casein at the rate of from two to six ounces per 100 gallons, according to the character of the juice. Lactocol is more convenient to use as it dissolves easily in warm water. Casein has to be dissolved with the aid of sodium carbonate or other alkali. Silicate of soda at the rate of 2 to 4 ounces per hundred gallons gave fair results.

Whenever the juice does not become bright by itself, fining is advisable. Even though the fining is not completely successful in clearing the juice, its use much facilitates the final filtration.

*The juice may be filtered a few hours after heating with the finings. It will usually remain bright after this but will deposit cream of tartar.

OUTLINE OF RECOMMENDED METHODS.

1. Domestic Method—
   Separation of Juice
   Sulfiting, Defecation and Settling—24 to 48 hours
   Bottling and Sterilizing for 30 minutes at 165° F.
2. Industrial Method—
   Separation of Juice
   Sulfiting, Defecation and Settling—24 to 48 hours
   Removal of Juice from Sediment
   (Addition of Finings)
   Heating to 165° F.
   Settling for one week to three months.
   Removal of Juice from Sediment
   (Addition of Citric Acid)
   Filtering (if necessary)
   Bottling
   Sterilization at 160° F for twenty minutes.

VARIETIES OF JUICE.

Much variety in color and flavor can be given to Californian grape juice by the use of different varieties of grapes and by modifications in the methods of manufacture.

The finest and most highly flavored juice can be made only from thoroughly mature grapes, in perfect condition, of the best varieties. However, any variety of vinefera grapes, even if not in the best condition, such as good table grape culls, if treated carefully as described, will produce a very acceptable juice of much higher quality than most of that which appears in the market either under a Californian or an Eastern label. Much of the juice is defective in flavor and appearance because of overheating and over exposure to the air or other unsuitable treatment.

Where a choice is possible, grapes of high acidity should be used. This does not mean unripe grapes, for the full delicious flavor of the grapes does not develop until the grapes are quite mature. It means grapes which retain their acidity even when they are ripe. Any grape which will make good wine will make good grape juice and the best for one purpose is the best for the other. An exception should be made of the Pierce and other Labrusca varieties, which make good grape juice but are unsuitable for wine.

Many Californian grapes tend to be very rich in sugar and rather low in acidity. This makes the juice more acceptable to some palates. To others, it is a defect, especially if the juice is diluted with water, when consumed. Most juice can be improved by the addition of a little citric acid, as already indicated. The excessive sweetness of the juice would be remedied by diluting with water, but it would seem more advisable to allow the consumer to do this to his own taste.

The color of the juice can be modified in several ways. It may be made nearly water white or dark red. Many tints between these, varying from greenish yellow to golden or pink, may also be obtained. The

lightest colors are obtained by moderate aeration before sulfiting and as little aeration as possible after. By this means, juice without any reddish tint can be made even from red grapes. In this case, the aeration must be sufficiently prolonged to destroy any color which gets into the juice during the crushing and pressing of the skins and the sulfite should be added as soon as the coloring matter is oxidized. This oxidation is shown by the change of the pink color of the juice to brownish and the formation of minute brown solid particles of oxidized coloring matter.

Red juice can be made in three ways. One is to use grapes with colored juice such as the Bouschets. Such juice will be pink or light red. Another way is to heat the crushed red grapes before the complete separation of the juice and defecation. This may be done by heating all the grapes in a boiler or by heating a portion of separated juice and pumping it on to the skins. A temperature of 120° F. of the whole mass is sufficient to extract the color in several hours. At higher temperatures, the extraction is more rapid. This method is not advisable, as it exposes the hot juice too much to the air, makes it very astringent and injures the flavor. A better method is to separate and defecate the juice as usual and to color it with a deep red juice made from the skins of dark colored grapes. This red juice is made as described above after draining off some of the free run of juice.

In this way, the fresh flavor of the juice is injured very little by the small quantity of heated red juice added.

Varieties of Grapes. As already indicated, palatable grape juice can be made from any of our ripe grapes. For the best results, however, some care must be exercised in the choice, blending and degree of ripeness of the varieties.

What is required is full acidity and flavor. Up to a certain stage, the riper the grapes the fuller the flavor but the lower the acidity. Most of our varieties do not attain their full flavor until they have reached a stage of ripeness representing at least 22° Balling. For a good fresh-tasting juice, the acidity ought to be about the equivalent of .7 per cent to .8 per cent of tartaric acid.

The average composition of Californian grapes, based on seven hundred analyses of many varieties from many sections, is 23.4° Balling and .58 per cent acid. These grapes were gathered as nearly as possible when they were at the best stage for wine-making. To obtain a juice of the composition desired for grape juice, most varieties would have to be gathered less ripe than this. Varieties which retain their acidity to an advanced stage of ripeness are particularly suitable for grape juice as are also varieties with a high special flavor.

A list of such varieties, together with some typical analyses is given in the following table:

SOME VARIETIES SUITABLE FOR GRAPE JUICE.

Variety	Composition							
	Coast region				Interior			
	Ripe		Overripe		Ripe		Overripe	
	Sugar	Acid	Sugar	Acid	Sugar	Acid	Sugar	Acid
Varieties with Special Flavors.								
Muscat of Alexandria	-------	-------	-------	-------	21.83	.74	27.20	.54
Traminer	-------	-------	25.10	.38	-------	-------	-------	-------
Riesling, Franken	21.92	.50	25.45	.46	24.40	.50	-------	-------
Riesling, Johannisberg	22.15	.66	23.96	.46	-------	-------	-------	-------
Semillon	-------	-------	24.10	.41	21.50	.63	25.90	.32
Colombar	-------	-------	-------	-------	21.50	.68	25.50	.37
Cabernet Sauvignon	21.95	.77	25.34	.50	-------	-------	25.50	.39
Means	22.00	.64	24.79	.44	22.31	.64	26.03	.41
Varieties with High Acid.								
Folle Blanche	20.50	.80	23.10	.77	18.60	.61	23.80	.45
Burger	17.20	.99	22.60	.79	19.60	.56	23.24	.45
West's White Prolific	21.50	.92	25.20	.86	22.40	.77	25.12	.62
Varieties with High Acid and Color.								
Bouschet, Alicante	21.60	.92	23.70	.69	21.20	.65	22.30	.43
Gamai, Teinturier	21.93	.80	26.50	.70	-------	-------	26.90	.64
Gros Mansenc	20.20	1.39	23.25	1.15	24.35	.88	26.10	.47
St. Macaire	20.00	1.07	25.90	.66	21.90	.70	23.50	.56
Alicante Ganzin	-------	-------	-------	-------	-------	-------	-------	-------
Means	20.42	.98	24.32	.80	21.34	.70	24.42	.52
Zinfandel	23.20	.75	26.50	.65	23.59	.64	28.34	.39
Means of all	21.07	.87	24.63	.64	21.83	.65	25.29	.45

This table shows that all the highly flavored varieties are somewhat lacking in acidity when ripe whether grown near the coast or in a warmer region. The acid varieties have sufficient acidity when grown in the coast region even when overripe. In the warmer regions, however, even these varieties lose too much of their acidity if allowed to become overripe. The best quality would probably be obtained by blending the juice of highly flavored varieties when they were fully ripe with acid varieties gathered while the acidity was still high. For example: A mixture of Muscat showing 25° Bal. of sugar and .55 per cent acidity with West's White Prolific, showing 20° Bal. of sugar and .95 per cent acidity would give a juice of 22.5° Bal. and .75 per cent acidity. The Prolific would supply the acid and the fully ripe Muscat the flavor.

A series of tests of the sugar and the acid in Muscat grapes at various stages of ripeness gives an example of the changes which take place in the ratio between sugar and acidity.

COMPOSITION OF MUSCAT GRAPES AT VARIOUS STAGES OF RIPENESS.

	Sugar (Bal.°)	Acidity (as tartaric)
Edible	21.8	.72
Ripe	25.5	.63
	26.2	.62
	26.8	.50
Overripe	27.2	.54
	29.1	.54
	33.2	.70

With a sugar content of 21.8° Bal., the grapes were edible and the acid sufficiently high but the full Muscat flavor had not developed. When the sugar had risen to 25.5° Bal. the flavor was fully developed but the acidity was a little low. This was the best stage to gather these grapes for grape juice. As they got riper, the acidity fell until at full ripeness (the stage for raisin making), nearly one third of the acidity was lost. The apparent increase of acidity with overripeness does not indicate a gain of acid but simply concentration due to evaporation of water.

As a general rule, the grapes for flavoring should be gathered when the sugar reaches 23° to 25° Balling and the grapes for acidity when it reaches 19° to 21° Bal.

Eastern Varieties. Grape juice made in New York and other eastern states is sold in large quantities even in California. Various samples show variations in quality, but they all differ from the Californian juices in their higher acidity and their strong Labrusca flavor. We can obtain the acidity by gathering our grapes with the low percentage of sugar customary in the East. The Labrusca flavor we can obtain only by growing the Eastern grapes. These grapes, Concord, Isabella, Catawba, etc., do very well in the cooler parts of California, bearing larger crops of sweeter grapes than they do in most Eastern vineyards. The Pierce, an improved Isabella, would probably be very suitable for producing a Californian grape juice of the Eastern type.

Which would be more profitable, to produce grape juice from Labrusca varieties, thus taking advantage of a market already established, or to develop the market for juice made from our Californian varieties, experience alone can determine. There can be little doubt that both kinds of grape juice can be produced here profitably when the manufacturers adopt methods which will insure the conservation of the good qualities of our grapes.